Sub-nanogram Pb isotope analysis of individual melt inclusions

Bracco Gartner, Antoine J.J.; Davies, Gareth R; Koornneef, Janne

2020

DOI (link to publisher)
10.46427/gold2020.247

Sub-nanogram Pb isotope analysis of individual melt inclusions

A.J.J. BRACCO GARTNER[1]*, G.R. DAVIES[1] AND J.M. KOORNNEEF[1]

[1]Vrije Universiteit Amsterdam, The Netherlands (*correspondence: a.j.j.braccogartner@vu.nl)

Precise analysis of $^{20x}Pb/^{204}Pb$ ratios is challenging when the amount of Pb is limited by sample volume or elemental concentration. The current precision impedes meaningful analyses of analytes with sub-nanogram Pb contents, such as individual melt inclusions with typical diameters (<100 µm). Decreasing this lower limit whilst maintaining precision and accuracy is crucial for studies aiming to understand the composition and heterogeneity of melt source regions, and the effects of magma transport from the Earth's interior.

The preferred method for precise analysis of sub-nanogram Pb samples combines miniaturised ion-exchange separation, a Pb double spike, and thermal ionisation mass spectrometry (TIMS) with 10^{13} Ω amplifier technology. This approach allows for interference-free, instrumental mass fractionation-corrected isotope measurements, and therefore provides precision superior to *in situ* measurements. As a result, reliable analyses can be conducted on samples which contain only a few hundred picograms of Pb.

The principal obstacle at the lower limit is the analytical blank, which usually adds a few pg Pb—and thus up to a few percent—to the sample of interest. This contribution may differ for the ^{207}Pb-^{204}Pb-spiked and unspiked runs of one sample, which in turn convolutes the algebraic inversion of the spike. It is therefore imperative to evaluate the magnitude, isotope composition, and homogeneity of the blanks, and constrain how the uncertainty and potential variability within these parameters affect the inversion.

Here, we describe the optimised analytical techniques, and discuss the present feasibility and limitations in obtaining precise Pb isotope compositions of rock reference materials and olivine-hosted melt inclusions with sub-nanogram Pb contents. In addition, we discuss the effect of different blank contributions on double-spike analyses using numerical simulations, and evaluate the potential of accurate blank corrections. We find that the optimised technique allows accurate Pb analyses to be conducted on melt inclusions with >200 pg Pb, which will ultimately help to better constrain mantle heterogeneity beneath mid-ocean ridges, oceanic islands, and volcanic arcs.